

# The Future of Manufacturing

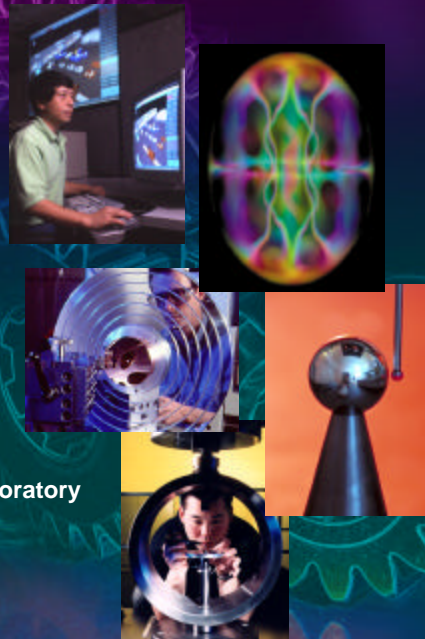
- Dale Hall  
Director, Manufacturing Engineering Laboratory
- Thomas A. Cellucci  
Chief Operating Officer, Zyvex
- Larry Rhoades  
President, Extrude Hone Corp.
- Richard Smith  
Exec. VP, Maxwell Technologies

manufacturing at the national institute of standards and technology

## Future of Manufacturing

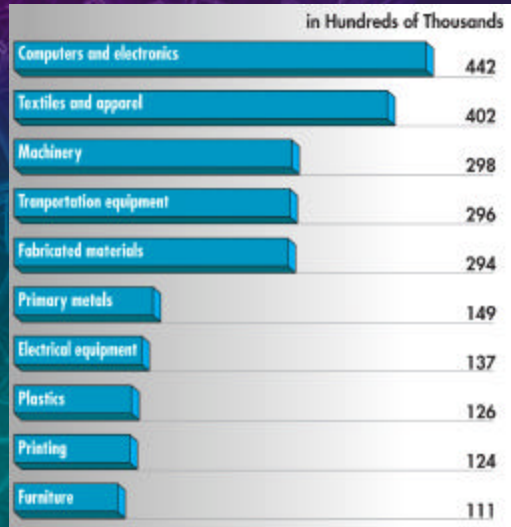
**Dale Hall**  
**Director**  
Manufacturing Engineering Laboratory

**NIST** National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce



## U.S Manufacturing jobs were cut mainly from these categories

Since July 2000, 2.7 million manufacturing jobs lost



Source: Labor Department, printed in The Washington Post on Nov. 2, 2003

manufacturing at the national institute of standards and technology

## Smart manufacturing: EU Research sparks revolution in machine tools, robots and automation

### Flexible manufacturing: key to a competitive economy

Advanced manufacturing is one of Europe's key strengths in the global market. Currently, **Europe dominates the global machine tool and automation markets, providing some 52% of the world-wide value of machine tool production in 2002 (Japan 20%, China 9.6% USA 6.1%)** and is at the cutting edge of research and technological developments in that area. Research and innovation in machine tools, robots and automation provide a key building block for economic performance, making other EU industries more competitive.

European Commission News Release, October 22, 2003

manufacturing at the national institute of standards and technology



## Manufacturing Processes

### *Perspective*

Manufacturing processes will become more automated and technologically complex

- Higher level job functions and education requirements
  - A well-educated workforce is a key national asset
- Productivity will continue to increase
  - Work requirements per capita may decrease
  - Similar to the path taken by agriculture?
- Manufacturing will become more agile and flexible
- Innovate or risk losing out

manufacturing at the national institute of standards and technology



## Manufacturing Products

### *Perspective*

- Manufactured products will become more technologically sophisticated
  - Customers will demand new attributes and performance never before possible
  - Personal empowerment in work and leisure will be key selling points
  - Products will respond to high-level social concerns: e.g., fossil fuel depletion, environmental issues, safety, and security
  - Products will be more highly customized to cater to individual preferences

manufacturing at the national institute of standards and technology



## Manufacturing Enterprise *Perspective*

- The manufacturing enterprise will continue to become more distributed and complex
  - Enterprise management/integration will be a major competitive factor
  - Pressure may fall disproportionately on smaller companies – unless OEMs and suppliers work together
  - Enterprise integration is an infrastructure issue; a coordinated approach will be most productive and efficient

manufacturing at the national institute of standards and technology



## Globalization *Perspective*

- Globalization is here to stay
  - The goal must be to thrive in a global economy, not prevent it
  - Virtually every major industry could be affected, including some that may not see it coming
  - Competing on the basis of labor rates is not feasible for the U.S.
  - Must preserve core functions, unique knowledge, high value-add for economic and national security
  - Technology is a key competitive tool but is not being viewed or applied strategically

manufacturing at the national institute of standards and technology



## Political Awareness

### *Perspective*

- Political concern about manufacturing is primarily a job loss issue
  - awareness is welcome – but how do we define success? Financial health of firms? Gaining/ saving jobs?
  - Service industries are no safe haven
    - Services also are being sent offshore
    - Increasing automation/improved efficiencies also have impact

manufacturing at the national institute of standards and technology



## Creating a Competitive Advantage

- Is there a coordinated national strategy for manufacturing
  - A desirable and realizable future
  - How we would get there
- A superior infrastructure provides a counter to labor rate differentials
- Providing the technology infrastructure is NIST's role:
  - Measurement methods
  - Calibration Services
  - Standard Reference Materials
  - Evaluated scientific data
  - Standards development
  - Collaborative R&D
  - Testing laboratory accreditation

manufacturing at the national institute of standards and technology

# National Institute of Standards and Technology

Our Mission: Develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.



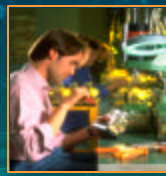
## Laboratories

Measurement  
Standards  
Technology



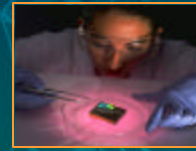
## Baldrige National Quality Program

Quality Practices



## Manufacturing Extension Partnership

Business and  
Technical Assistance  
to SMEs



## Advanced Technology Program

Innovative  
Technology  
Partnerships

manufacturing at the national institute of standards and technology

## Measurements and Standards for Making Things...

...Right

...Interoperable

...Traceable

...Small

manufacturing engineering laboratory • measuring for success




## Making Things... Right

- Product quality and manufacturing agility suffer from:
  - Outdated, empirical processes and models
  - Lack of tools and methods for sharing predictive knowledge
  - A lack of smart tools with self knowledge, error compensation, and maintenance prediction




manufacturing at the national institute of standards and technology



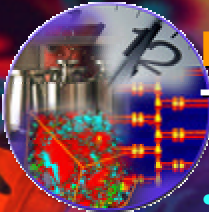
## Making Things... Right (continued)

**NIST Response:**

- Measurement methods, characterization, modeling, tests, data, standards and/or tools for:
  - Virtual prototyping and manufacturing process simulation
  - Advances in biomolecular and biomaterials manufacturing
  - Understanding and predicting the performance of high-performance concrete and other advanced building materials
  - Accurate and consistent specifications for appearance and functionality of coatings and surfaces
  - Smart machine tools that can learn, self-correct, and communicate
  - A virtual cybernetic building for evaluating new products and systems such as fire detection and security systems

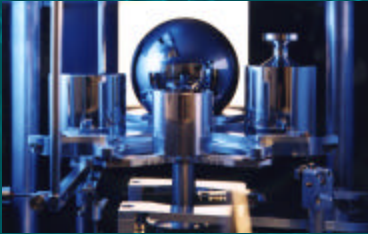


manufacturing at the national institute of standards and technology

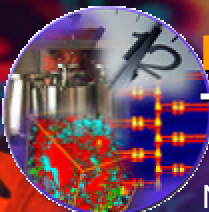


## Making Things... Traceable

- Measurement traceability assures the uniformity and quality of manufactured parts and industrial processes
- Accepted, traceable measurements are key to lower market transaction costs, extended supply chains, and global trade



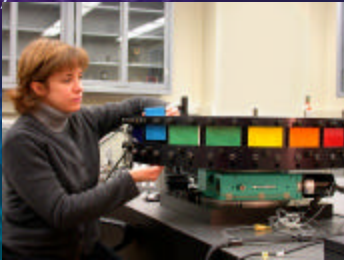
manufacturing at the national institute of standards and technology



## Making Things... Traceable (continued)

NIST Response:

- Realization and dissemination of measurements in:
  - Mechanical Metrology – force, mass, acoustics, & vibration
  - Dimensional Metrology – over 13 orders of magnitude ranging from sub-nanometer to hundreds of meters
  - Process Metrology – temperature, pressure, vacuum, fluid & gas flow, liquid density and volume
  - Electromagnetic Metrology – volt, ohm, and amp
  - Optical radiation metrology – non-contact thermometry, etc.



manufacturing at the national institute of standards and technology



## Making Things... Interoperable

- The modern extended manufacturing enterprise depends on sharing technical and business information
- Three critical needs must be addressed:
  - **Structural** – reliable, seamless, and accurate information and knowledge transfer
  - **Economic** – affordable solutions for all players
  - **Security** – need to make the infrastructure more robust

manufacturing at the national institute of standards and technology



## Making Things... Interoperable (continued)

NIST Response:

- Critical Infrastructure Protection (e.g., power grid and water distribution)
- Integrated Construction Environments
- Intelligent Control Systems
- Manufacturing Enterprise Integration
- Manufacturing Simulation and Visualization
- Electronic Commerce
- Healthcare Enterprise Integration



manufacturing at the national institute of standards and technology

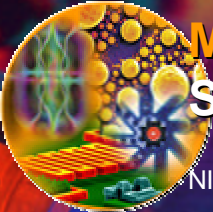


## Making Things... Small

- Nanotechnology will revolutionize many industries and yield new high-tech products
- Nanomanufacturing is the link between discoveries and products
- Both Nanotechnology and Nanomanufacturing will require:
  - Atomic level accuracy and repeatability
  - Ability to achieve desired performance attributes
  - Commercially viable costs



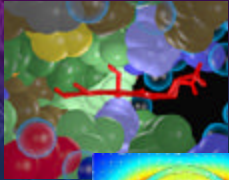
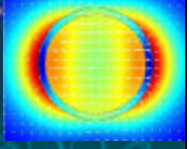
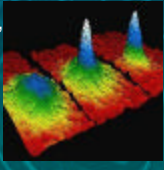

manufacturing at the national institute of standards and technology



## Making Things... Small (continued)

NIST Response:

- Atom-based standards
- Nano-to-Millimeter Manufacturing Technologies
- Metrology for semiconductor & microelectronics
  - Linewidth, step heights, nanoelectronic devices, electronic materials, and system-on-a-chip
- Molecular electronics – test structures, methods, and metrology to measure the electrical properties of small ensembles of molecules for electronic nanodevices
- Combinatorial chemistry – high-throughput measurement techniques and combinatorial experimental strategies
- Nanofluidics – metrology methods and tools to characterize the performance of nano-fluidic devices and structures

manufacturing at the national institute of standards and technology

## A Technology Infrastructure Is Built on Partnerships

